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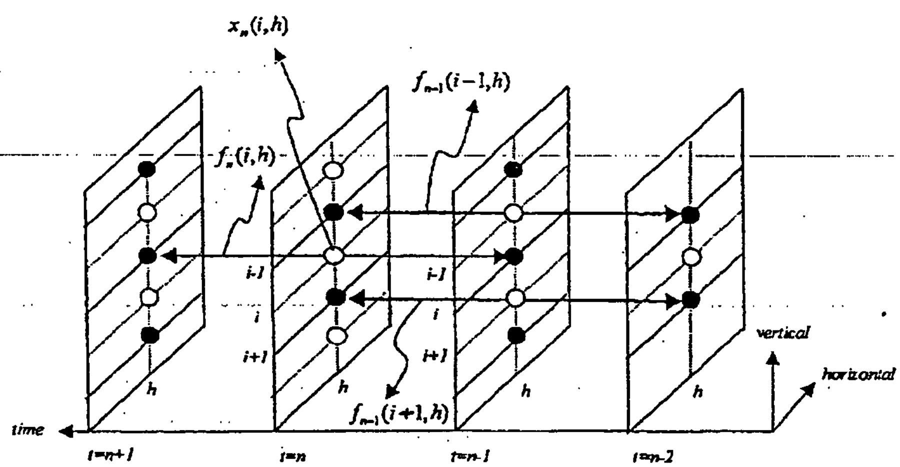
(54) **Motion detection in an interlaced video signal**

(57) A motion decision value provides a dependable estimate whether motion occurs in a given region of a video image in an interlaced video sequence. The motion detection is particularly applicable in the conversion from interlaced video to progressive video. An input first is fed to an absolute value former which computes a frame difference signal from a difference between the first field and the second field in one frame. A point-wise motion detection in the frame difference signal is then followed by a region-wise motion detection that combines the point-wise motion detection signal with an adjacent point-wise motion detection signal delayed by one field. The motion decision value is then computed from the region-wise motion detection signal and output for further processing in the video signal processing system, such as for choosing whether the spatially interpolated video signal value or the temporally interpolated video signal value should be used for the output.



$$\phi(i,h) = f_n(i,h) \,\|\, f_{n-1}(i-1,h) \,\|\, f_{n-1}(i+1,h).$$

FIG 3

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Description

[0001] The present invention relates to a method of detecting motion in an interlaced video signal, the method comprising receiving a series of video frames; and for each frame, determining a difference value for the difference between each of its pixels and corresponding pixels in the preceding frame, if any, and an apparatus therefor.

[0002] Since different digital television (DTV) standards have been adopted in different parts of the world, it hs become desirable to employ video format conversion units in digital televisions. The ATSC DTV standard system of North America, for example, adopted 1080x1920 interlaced video, 720x1280 progressive video, 720x480 interlaced and progressive video, and so on, as its standard video formats for digital TV broadcasting.

[0003] Video format conversion refers to a signal processing operation in which an incoming video format is converted to a different output video format so that the output video can be properly displayed on a displaying device such as a monitor, FLCD, or a plasma display, which has a fixed resolution.

[0004] Video format conversion systems are of significant importance since the conversion can directly affect the visual quality of the video of a DTV receiver. Fundamentally, the video format conversion operation requires advanced algorithms for multi-rate system design, poly-phase filter design and interlaced-to-progressive scanning rate conversion or simply deinterlacing. Deinterlacing is an operation that doubles the vertical scanning rate of the interlaced video signal.

[0005] Interlaced video comprises a sequence of separately arriving fields, such as A1, A2, A3, etc., where A1 and A3 are top imagea and A2 being a bottom image. The top and bottom images are also known as the odd and even fields. The most popular systems currently in use, namely NTSC, PAL, and SECAM are two-field systems, where two consecutive fields (such as the top field A1 and the bottom field A2) make up a frame. Each scanned field contains, i. e., updates, every other line of a corresponding frame and the number of lines in the frame is twice the number of lines in each of the fields. Typically, the first field of a frame is identified with odd-numbered lines and the second field is identified with even-numbered lines. The fields are scanned onto the display screen one after the other at a defined frequency.

[0006] By way of example, NTSC operates at 30 frames (60 fields of interlaced video) per second, with 525 lines per frame, and a horizontal to vertical aspect ratio of 4:3. The frame difference, therefore, is the difference between two fields having the same types (top or bottom) such as A1 and A3, or A2 and A4. PAL and SECAM operates at 25 frames per second, with 625 lines per image, and the same aspect ratio of 4:3. As noted, the interlacing in all of these systems is 2:1, i.e., two fields per frame. The primary reason for the interlacing of the lines between the fields is to reduce flicker in the display. An image that is updated, say, only 30 times a second would allow the human eye to perceive the scanning, because the image information would already start to fade before the next image is scanned onto the screen. When two fields are used, and each contains half of the information, the scanning rate in effect is raised to 60 Hz, and the human eye no longer perceives any flicker.

[0007] Deinterlacing refers to the filling of unavailable lines in each of the fields A1, A2, A3, and so on. As a result of deinterlacing, a 60 Hz field sequence (of interlaced video fields) becomes a 60 Hz progressive sequence.

[0008] Interlaced video is subject to several intrinsic drawbacks, referred to as artifacts. These include serrated lines that are observed when there is motion between fields, line flickering, raster line visibility, and field flickering. These also apply to DTV (digital TV) receivers. Historically, deinterlacing algorithms have been developed to enhance the video quality of NTSC TV receivers by reducing these intrinsic annoying artifacts of the interlaced video signal. Besides, elaborate deinterlacing algorithms utilizing motion detection or motion compensation provide excellent methods of doubling the vertical scanning rate of the interlaced video signal especially for stationary (motionless) objects in the video signal.

[0009] The present invention therefore also relates to the motion detection based deinterlacing operation that can be used for analogue and digital TV receivers.

[0010] The state of the art includes a variety of deinterlacing algorithms, each having been exploited and studied comprehensively by many researchers during the last decade. Deinterlacing algorithms can be categorized into two classes, namely, 2-D (spatial) deinterlacing algorithms and 3-D (spatio-temporal) deinterlacing algorithms depending on the use of motion information embedded in a video sequence. Combined spatial and temporal 3-D deinterlacing algorithms based on a motion detection give more pleasing performance than 2-D deinterlacing algorithms. The key point of a 3-D de-interlacing algorithm is how to precisely detect motion in the interlaced video signals. The publications in the following list disclose some of the applicable de-interlacing methods. They may be categorized as follows:

[1] Simple line doubling scheme, vertical filtering, vertical edge controlled interpolation method disclosed in the IEEE Transactions on Consumers Electronics, pp. 279-89, August 1989 by D.I. Hentschei;

[2] Edge direction dependent de-interlacing method disclosed in the Proc. of the Int. Workshop on HDTV, 1994, by D. Bagni, R Lancini, and S. Tubaro;

[3] Nonlinear interpolation methods based on:

- a weighted median filter disclosed in the Proc. of the IEEE ISCAS, pp. 433-36, Portland, USA, May 1989, by J. Juhola, A. Nieminen, J. Sal, and Y. Neuvo,
- FIR median hybrid interpolation disclosed in Pro. Of SPIE's Visual Communications and Image Processing, Lausanne, Switzerland, October 1990, 00. 125-32 by A. Lehtonen and M. Renfors,
- a complementary median filter disclosed in Proc. of the Int. Workshop on HDTV, 1994 by H. Blume, I. Schwoerer, and K. Zygis,

[4] A motion adaptive method disclosed in IEEE Transactions on Consumer Electronics, pp. 110-114, May 1990 by C. Markhauser.

More recently, a new motion-detection-based de-interlacing method has been described in the following two patents:

[5] US-A-5943099

This patent discloses an interlaced-to-progressive conversion device which includes a spatial interpolator that provides for spatial interpolation and a temporal interpolator that provides for temporal interpolation of an interlaced video input signal. The system reduces jitter and related artifacts by temporally or spatially interpolating the signals.

[6] US-A-5959681

In this patent, two separate field memories are utilized for detecting rapid motion and slow motion in an interlaced video sequence. An interlaced video signal is thereby converted into a progressive-scanned signal. Differences between spatial interpolation and temporal interpolation are used to determine whether the image is in motion. If the differences exceed certain defined thresholds, motion is determined. The thresholds are dynamically adapted during the process.

[0011] The core of the methods described in the aforementioned two patents is to determine a motion decision factor based on the frame difference signal and the sample correlation in the vertical direction. These methods provide a way of reducing the visual artifacts that can arise from false motion detection by utilizing sample correlation in the vertical direction where the value is to be interpolated. A common drawback of these methods, however, is that they do not provide a true motion detection method when there are high frequency components in the vertical direction. In other words, when there are high frequency components in the vertical direction, the methods described in the aforementioned patents will falsely determine that motion-containing pictures are being processed.

[0012] As a consequence, in many instances, these prior art processing methods do not provide for an increase in the vertical resolution even when no real motion is present between fields.

[0013] A method according to the present invention is characterised by further processing said determined differences, said further processing including deriving a motion signal for each pixel in dependence on the determined difference for that pixel and the determined difference for neighbouring pixels.

[0014] Preferably, said further processing comprises low-pass filtering the determined difference value space comprising said difference values for each frame and said motion signals are derived from the filtered difference values for each pixel and the filtered difference values for neighbouring pixels.

[0015] Preferably, said further processing comprises comparing said filtered difference values with a reference to produce respective binary difference values and said motion signals are derived for each pixel from the result of ORing its binary difference value with those of said neighbouring pixels.

[0016] Preferably, a method according to the present invention includes low-pass filtering the space comprising the results of said ORing for a frame to produce said motion signals.

[0017] Said neighbouring pixels may be temporally or spatially neighbouring.

[0018] The present invention also provides an apparatus comprising means for performing each of the steps of a method according to the present invention.

[0019] Embodiments of the present invention, will now be described, by way of example, with reference to the accompanying, drawings in which:

Figure 1 is a diagrammatic view of two adjacent fields of a frame of an interlaced video signal;
Figure 2 is a diagrammatic illustration of three fields for illustrating the de-interlacing problem;
Figure 3 is a more detailed view illustrating the de-interlacing process;
Figure 4 is a block diagram illustrating the computation of a motion decision parameter; and
Figure 5 is a block diagram showing the computation of the motion decision parameter and the resultant mixing of the spatially and temporally interpolated signals in dependence on the motion decision.

[0020] Referring to Figure 1, an interlaced video signal is a series of frames each including a plurality of fields. As noted above, all conventional systems utilize two fields per frame which are sequentially scanned. A top field 1 contains information regarding the first ($v = 0$), third ($v = 2$), fifth ($v = 4$), etc. lines, and a bottom field 2 contains information regarding the second ($v = 1$), fourth ($v = 3$), sixth ($v = 5$), etc. lines.

[0021] In order to systematically describe the de-interlacing problem and the methods of the present invention, let x_n denote the incoming interlaced video field at a time instant $t = n$ and $x_n\ (v,h)$ denote the associated value of the video signal at the geometrical location (v,h). The variable v represents the vertical location and h represents horizontal location, in the cartesian co-ordinate system commonly used. By definition, the signal values of x_n of the interlaced video signal are available only for the even lines ($v = 0,2,4,\ldots$) if x_n is the top field 1. Similarly, the signal values of x_n are available only for the odd lines of v ($v = 1,3,5,\ldots$) if x_n is the bottom field 2. Conversely, the signal values of x_n are not available for odd lines if x_n is a top field signal and the signal values of x_n are not available for even lines if x_n is a bottom field. Figure 1 shows the top field 1 scanned at $t = m$ and the bottom field 2 scanned at $t = m + 1$. Top and bottom fields are typically available in turn in the time axis, that is, pairs comprising top and bottom fields are used to make up frames.

[0022] The de-interlacing function can be defined as a process to reconstruct or interpolate the non-available signal values of each field. That is, the de-interlacing function is to reconstruct the signal values of x_n at the odd lines ($v = 1,3,5,\ldots$) for the top field x_n and to reconstruct the signal values of x_n at the even lines ($v = 0,2,4,\ldots$) for the bottom field x_n.

[0023] For the simple description of the present invention, and to avoid any notational confusion in the disclosure, the de-interlacing problem will be simplified as a process which reconstructs or interpolates the unavailable signal value of x_n at the i^{th} line where the signal values of the lines at $i\pm1$, $i\pm3$, $i\pm5$,... are available. More simply de-interlacing is to interpolate the value of $x_n(i,h)$, which was not originally available. It must be noted that, since x_{n-1} and x_{n+1} have a different sampling phase from x_n, the signal values of $x_{n-1}(i,h)$ and $x_{n+1}(i,h)$ are available, which is why motion detection can be incorporated with the de-interlacing function. This relationship is depicted in Figure 2, where dotted lines (and white circles) represent "no data available" and solid lines (and black circles) represent "available data."

[0024] Referring now to Figures 3, 4 and 5, there is illustrated a method of estimating a motion decision parameter $m_n(i,h)$. Fundamentally, $m_n(i,h)$ is estimated from the incoming interlaced video sequence and associated with the point-to-point degree of motion in the interlaced video sequence. The importance or the usefulness of estimating $m_n(i,h)$ can be easily understood from Figures 2 and 3. Suppose that precise motion detection information is available when we interpolate $x_n(i,h)$ and suppose there is no motion at the spatial location (i,h), then the best interpolation for $x_n(i,h)$ is to use the value of $x_{n-1}(i,h)$. This follows logically from the fact that no motion is introduced between $t = n - 1$ and $t = n + 1$ at the spatial location (i,h), which very strongly implies that the value of $x_n(i,h)$ would be close to the value of $x_{n-1}(i,h)$. The usage of the motion decision parameter of the present invention is also to utilize the motion information for de-interlacing to properly mix the temporal information, which will be described later.

[0025] First, the frame difference signal D_n is computed by taking the difference between the fields in one frame interval as

$$D_n = |x_{n+1} - x_{n-1}|$$

which is associated with the scene change that occurred between the fields x_{n+1} and x_{n-1}. The frame difference signal is then low-pass filtered to form

$$d_n = LPF(D_n)$$

where LPF() represents a low-pass filtering process. The M x N kernel, $W_{M\times N}$, in general, of the low-pass filter LPF(), can be expressed as

$$W_{M\times N} = \begin{bmatrix} w_{11} & w_{12} & \Lambda & w_{1N} \\ w_{21} & w_{22} & \Lambda & w_{2N} \\ \mathrm{M} & \mathrm{M} & \mathrm{O} & \mathrm{M} \\ w_{M1} & w_{M2} & \Lambda & w_{MN} \end{bmatrix}$$

where (w_{11}, ..., w_{MN}) represents a set of predetermined coefficients. It should be noted that the characteristic of the low-pass filter can be all-pass filter depending on the choice of the kernel W_{MxN}. That is, if the kernel is set as $M = N = 1$, and $w_{11}=1$, the LPF() becomes an all-pass filter and, thus, $d_n = D_n$.

[0026] Next, a point-wise motion detection signal is computed using

$$f_n(i,h)=T_K(d_n(i,h)) \qquad (1)$$

where $T_K()$ denotes a threshold function represented by

$$T_k(y)=\begin{cases}1, \text{if } y \geq K \\ 0, \text{otherwise}\end{cases}$$

in which K is a positive constant value. Then the region-wise motion detection signal is computed from the point-wise motion detection signals which logically combines the signals according to:

$$\phi_n(i,h)=f_n(i,h) \| f_{n-1}(i-1,h) \| f_{n-1}(i+1,h)$$

where $f_{n-1}(i-1,h)$ denotes the one-field delayed motion detection signal described in (1) and where the notation $\|$ denotes the logical OR operation.

[0027] Finally, the region-wise motion detection signal is low-pass filtered to form the motion decision parameter $m_n(i,h)$, namely:

$$m_n(i,h)=\sum_{p=-a}^{b}\sum_{q=-c}^{d}\phi_n(i+2\times p,h+2\times q)\cdot\alpha_{p,q} \qquad (2)$$

where a,b,c,d $\geq$ 0, and $\alpha_{p,q}$ represents a set of normalized (i.e.

$$\sum_{p=-a}^{b}\sum_{q=-c}^{d}\alpha_{p,q}$$

), predetermined coefficients of a low-pass filter. For instance, the kernel of the low-pass filter used in (2) can be

$$\left[\alpha_{p,q}\text{'s}\right]=\begin{bmatrix}0 & 1/8 & 0\\ 1/8 & 4/8 & 1/8\\ 0 & 1/8 & 0\end{bmatrix}$$

[0028] Figure 4 illustrates the computation of the motion decision parameter $m_n(i,h)$ as described above. The computed motion decision parameter $m_n(i,h)$ is then used to mix a spatially interpolated signal and a temporally interpolated signal, as illustrated in Figure 5.

[0029] Referring to Figure 5, an interpolation apparatus comprises a spatial interpolator 3, a temporal interpolator 4, a motion decision processor 5, and a mixer 6. The decision processor 5 corresponds to Figure 4 and includes, in the signal flow direction, an absolute value former 51 which defines the absolute difference parameter D_n; a first low-pass filter LPF 52 in which the filtering function W_{MxN} with the MxN kernel is set; an adjustable or fixed threshold member 53 which, in a preferred embodiment, is implemented by a controlled comparator; a buffer memory 54 and a further line memory 55 are connected to an OR logic circuit 56 in which the function signal $\phi_n(i,h)$ is formed as described above;

finally, the motion detection signal $m_n(i,h)$ is formed by low pass filtering in a spatial low-pass filter LPF 57. The output of the low-pass filter 57 is connected so that the motion detection signal $m_n(i,h)$ is supplied to a control input of the mixer 6.

[0030] The spatial interpolator 3 spatially interpolates the value of $x_n(i,h)$ by using a predetermined algorithm. The temporal interpolator 4 temporally interpolates the value of $x_n(i,h)$ by using a predetermined algorithm. The motion decision value $m_n(i,h)$ computed in the motion decision processor 5, as described above, represents the degree of motion at the interpolation location (i,h). Conceptually, the value of the motion decision parameter will be bounded as $0 (m_n(i,h) (1$ where the extreme $m_n(i,h) = 0$ implies "no motion" and $m_n(i,h) = 1$ implies "motion". The mixer mixes the output signal of the spatial interpolator and the output signal of the temporal interpolator in accordance with the motion decision value. Taking $x_n^s(i,h)$ and $x_n^t(i,h)$ the output signal of the spatial interpolator and the output signal of the temporal interpolator, respectively, the output signal of the mixer, or, the interpolated signal is represented by

$$x_n(i,h)=(1-m_n(i,h))\cdot x_n^t(i,h)+m_n(i,h)\cdot x_n^s(i,h)$$

[0031] It is clear that $x_n(i,h)=x_n^t(i,h)$ when $m_n(i,h)=0$ (no motion) and $x_n(i,h)=x_n^s(i,h)$ when $m_n(i,h)=1$ (motion).

[0032] It will be understood that it does not matter what kind of spatial interpolating algorithm (in the spatial interpolator 3) and what kind of temporal interpolating algorithm (in the temporal interpolator 4) are used for the interpolation. The present invention is only concerned with estimating the motion decision value $m_n(i,h)$ and with mixing a spatially interpolated signal and a temporally interpolated signal in accordance with the estimated motion decision value.

[0033] Specific information with regard to the interpolation of interlaced video signals and interlaced to progressive conversion is readily available to those of skill in the pertinent art.

[0034] Some examples of the spatially interpolated signal $x_n^s(i,h)$ are

$$x_n^s(i,h)= {}^{(x_n(i-1,h)+x_n(i+1,h))}/_2$$

which corresponds to a line average and

$$x_n^s(i,h)=x_n(i-1,h)$$

which corresponds to a method known as line doubling.

[0035] Also, some examples of temporally interpolated signal $x_n^t(i,h)$

$$x_n^t(i,h)= {}^{(x_{n+1}(i,h)+x_{n-1}(i,h))}/_2$$

and

$$x_n^t(i,h)=x_{n-1}(i,h)$$

Claims

1. A method of detecting motion in an interlaced video signal, the method comprising:

   receiving a series of video frames; and
   for each frame, determining a difference value for the difference between each of its pixels and corresponding pixels in the preceding frame, if any,

   characterised by further processing said determined differences, said further processing including deriving a motion signal for each pixel in dependence on the determined difference for that pixel and the determined difference for neighbouring pixels.

2. A method according claim 1, wherein said further processing comprises low-pass filtering the determined difference value space comprising said difference values for each frame and said motion signals are derived from the filtered

difference values for each pixel and the filtered difference values for neighbouring pixels.

3. A method according to claim 2, wherein said further processing comprises comparing said filtered difference values with a reference to produce respective binary difference values and said motion signals are derived for each pixel from the result of ORing its binary difference value with those of said neighbouring pixels.

4. A method according to claim 3, including low-pass filtering the space comprising the results of said ORing for a frame to produce said motion signals.

5. A method according to any preceding claim, wherein said neighbouring pixels are temporally neighbouring.

6. A method according to any one of claims 1 to 4, wherein the neighbouring pixels are spatially neighbouring.

7. In a video signal processing system, a method of computing a motion decision value, which comprises the following steps:

   inputting a video signal with an interlaced video sequence of fields; computing a frame difference signal from a difference between a previous field and a next field in the video sequence;
   forming a point-wise motion detection signal from the frame difference signal;
   computing a region-wise motion detection signal from the point-wise motion detection signal and an adjacent point-wise motion detection signal delayed by one field; and
   forming from the region-wise motion detection signal a motion decision value and outputting the motion decision value for further processing in the video signal processing system.

8. The method according to claim 7, which further comprises low-pass filtering the difference signal prior to the step of forming the point-wise motion detection signal.

9. The method according to claim 8, wherein the step of low-pass filtering is defined by a low pass filter matrix

$$W_{M \times N} = \begin{bmatrix} w_{11} & w_{12} & \Lambda & w_{1N} \\ w_{21} & w_{22} & \Lambda & w_{2N} \\ \mathrm{M} & \mathrm{M} & \mathrm{O} & \mathrm{M} \\ w_{M1} & w_{M2} & \Lambda & w_{MN} \end{bmatrix}$$

   where w_{11}, ... w_{MN} represent a set of predetermined coefficients.

10. The method according to claim 7, wherein the step of forming the point-wise motion detection signal comprises computing

$$f_n(i,h)=T_K(d_n(i,h))$$

   where f_n is the point-wise motion detection signal, i and h define a spatial location of the respective video signal value in a cartesian matrix, $T_K(\cdot)$ denotes a threshold function represented as

$$T_k(y)=\begin{cases} 1, \text{if } y \geq K \\ 0, \text{otherwise} \end{cases}$$

   in which K is a positive constant, and $d_n(\cdot)$ is the low-pass filtered frame difference signal.

11. The method according to claim 7, wherein the region-wise motion detection signal is computed from the point-wise motion detection signal by logically combining the point-wise motion detection signal f_n as

$$\phi_n(i,h)=f_n(i,h)\|f_{n-1}(i-1,h)\|f_{n-1}(i+1,h)$$

where $f_{n-1}(i-1,h)$ denotes the motion detection signal delayed by one field, the indices i and h define a spatial location of the respective video signal value in a cartesian matrix, and the notation $\|$ denotes a logical OR operation.

12. The method according to claim 7, which further comprises low-pass filtering the region-wise motion detection signal prior to the outputting step.

13. The method according to claim 12, wherein the region-wise motion detection signal is low-pass filtered to form the motion decision value $m_n(i,h)$ by:

$$m_n(i,h)=\sum_{p=-a}^{b}\sum_{q=-c}^{d}\phi_n(i+2\times p,h+2\times q)\cdot\alpha_{p,q}$$

where a,b,c,d ≥ 0, and $\alpha_{p,q}$ represents a set of normalized predetermined coefficients of a low pass filter.

14. The method according to claim 13, which comprises defining a kernel of the low pass filter as

$$[\alpha_{p,q}'s]=\begin{bmatrix}0 & 1/8 & 0\\ 1/8 & 4/8 & 1/8\\ 0 & 1/8 & 0\end{bmatrix}.$$

15. In a method of processing interlaced video signals, which comprises:

spatially interpolating a value of the video signal at a given location from a video signal of at least one adjacent location in a given video field;
temporally interpolating the value of the video signal at the given location from a video signal at the same location in temporally adjacent video fields; and
forming a motion decision value for the same location in accordance with claim 7; and
mixing an output signal for the video signal at the given location from the spatially interpolated signal and the temporally interpolated signal and weighting the output signal in accordance with the motion decision value.

16. The method according to claim 15, which comprises varying the motion decision value between 0 and 1 as a function of an estimate of the degree of motion at the given location and, upon estimating a high degree of motion, heavily weighting the output signal towards the spatially interpolated signal and, upon estimating a low degree of motion, heavily weighting the output signal towards the temporally interpolated signal.

17. The method according to claim 16, which comprises outputting the spatially interpolated signal as the output signal upon estimating a high degree of motion, and outputting the temporally interpolated signal as the output signal upon estimating a low degree of motion.

18. In a video signal processing system, an apparatus for computing a motion decision value, comprising:

an input for receiving a video signal with an interlaced video sequence;
difference forming means connected to said input for computing a frame difference signal from a difference between a previous field and a next field of a current field to be deinterlaced;
means for forming a point-wise motion detection signal from the frame difference signal, and for computing a region-wise motion detection signal from the point-wise motion detection signal and an adjacent point-wise motion detection signal delayed by one field; and
means for forming from the region-wise motion detection signal a motion decision value and for outputting the motion decision value for further processing in the video signal processing system.

19. The apparatus according to claim 18, which further comprises a low-pass filter connected to said difference forming means.

20. The apparatus according to claim 19, wherein said low-pass filter is programmed with a low pass filter matrix

$$W_{M\times N}=\begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N} \\ w_{21} & w_{22} & \cdots & w_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ w_{M1} & w_{M2} & \cdots & w_{MN} \end{bmatrix}$$

where $w_{11}, \ldots w_{MN}$ represent a set of predetermined coefficients.

21. The apparatus according to claim 18, which comprises a logic member programmed to compute the motion decision value from the point-wise motion detection signal by logically combining the point-wise motion detection signal f_n as

$$\phi_n(i,h)=f_n(i,h)\|f_{n-1}(i-1,h)\|f_{n-1}(i+1,h)$$

where $f_{n-1}(i-1,h)$ denotes the motion detection signal delayed by one field, the indices i and h define a spatial location of the respective video signal value in a cartesian matrix, and the notation || denotes a logical OR operation.

22. The apparatus according to claim 18, which further comprises a low-pass filter connected to an output of said outputting means.

23. The apparatus according to claim 22, wherein said low-pass filter is programmed to filter the region-wise motion detection signal to form the motion decision value $m_n(i,h)$ by:

$$m_n(i,h)=\sum_{p=-a}^{b}\sum_{q=-c}^{d}\phi_n(i+2\times p,h+2\times q)\cdot\alpha_{p,q}$$

where a,b,c,d ≥ 0, and $\alpha_{p,q}$ represents a set of normalized predetermined coefficients of a low pass filter.

24. The apparatus according to claim 23, wherein said low-pass filter is defined with a kernel

$$[\alpha_{p,q}'s]=\begin{bmatrix} 0 & 1/8 & 0 \\ 1/8 & 4/8 & 1/8 \\ 0 & 1/8 & 0 \end{bmatrix}$$

25. An apparatus of processing interlaced video signals, which comprises:

an input for receiving a video signal with an interlaced video sequence of fields;
a spatial interpolator connected to said input and configured to spatially interpolate a value of the video signal at a given location from a video signal of at least one adjacent location in a given video field;
a temporal interpolator connected to said input in parallel with said spatial interpolator for temporally interpolating the value of the video signal at the given location from a video signal at the same location in temporally adjacent video fields; and
a computing apparatus according to claim 12 connected to said input and in parallel with said spatial interpolator and said temporal interpolator for forming a motion decision value for the same location; and
a mixer connected to receive an output signal from each of said spatial interpolator, said temporal interpolator, and said computing apparatus, said mixer being configured to mix an output signal for the video signal at the

given location from the spatially interpolated signal and the temporally interpolated signal in dependence on the motion decision value output by said computing apparatus.

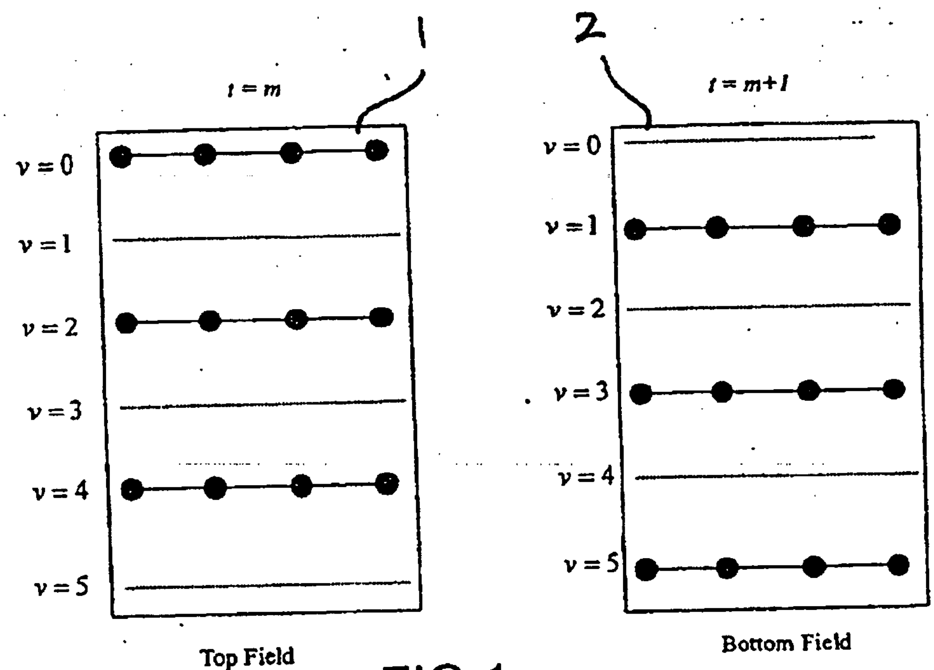

1
2
t = m
t = m+1
v = 0
v = 1
v = 2
v = 3
v = 4
v = 5
Top Field
Bottom Field

FIG 1

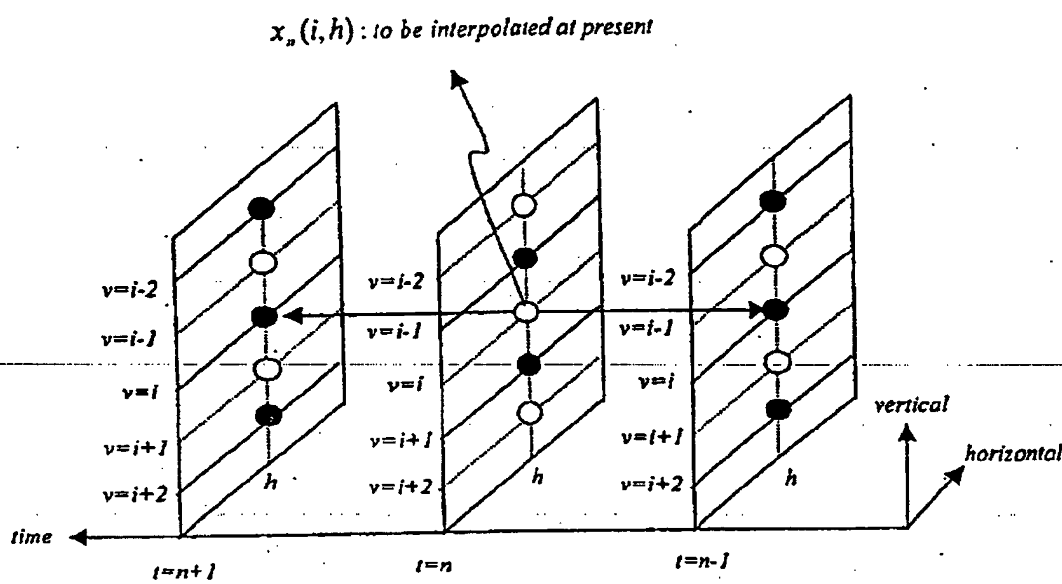
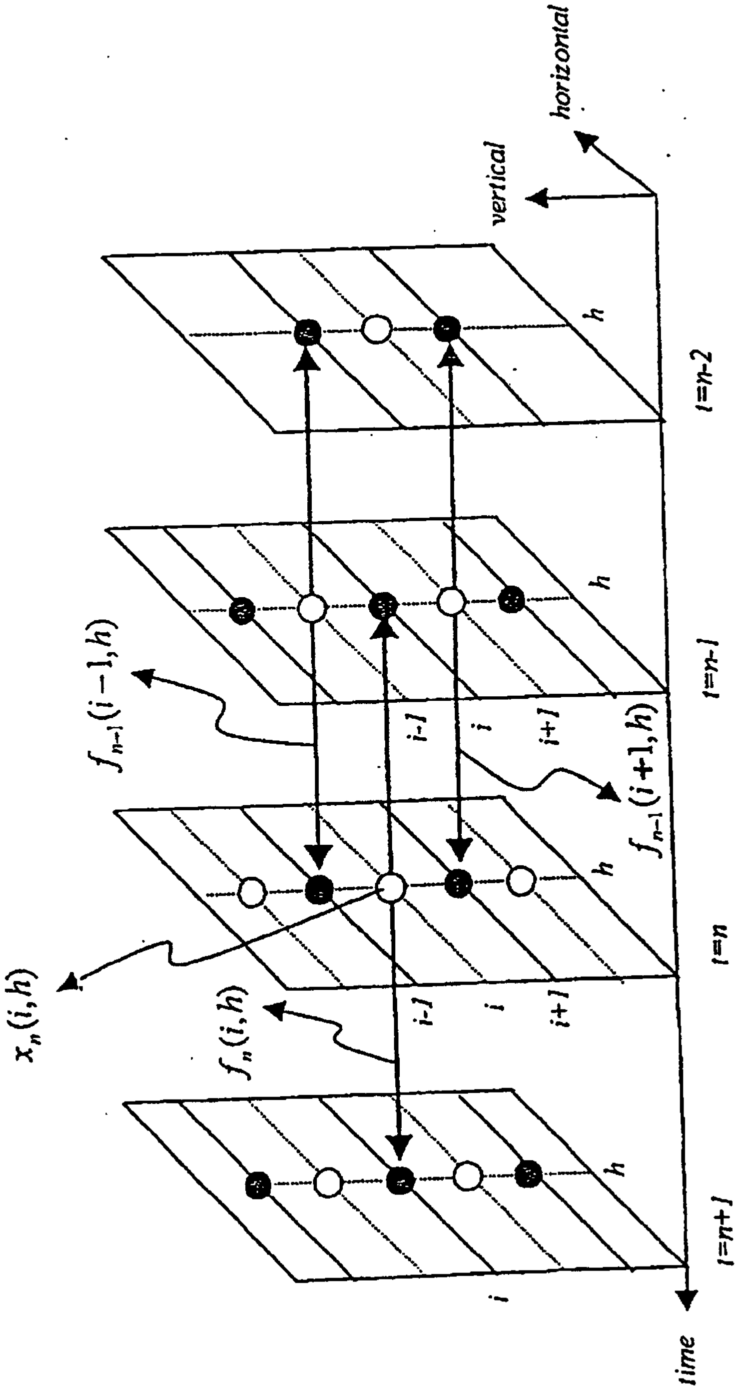

$x_n(i,h)$: to be interpolated at present
v=i-2
v=i-1
v=i
v=i+1
v=i+2
h
vertical
horizontal
time
t=n+1
t=n
t=n-1

FIG 2



$$\phi(i,h) = f_n(i,h) \,\|\, f_{n-1}(i-1,h) \,\|\, f_{n-1}(i+1,h).$$

FIG 3

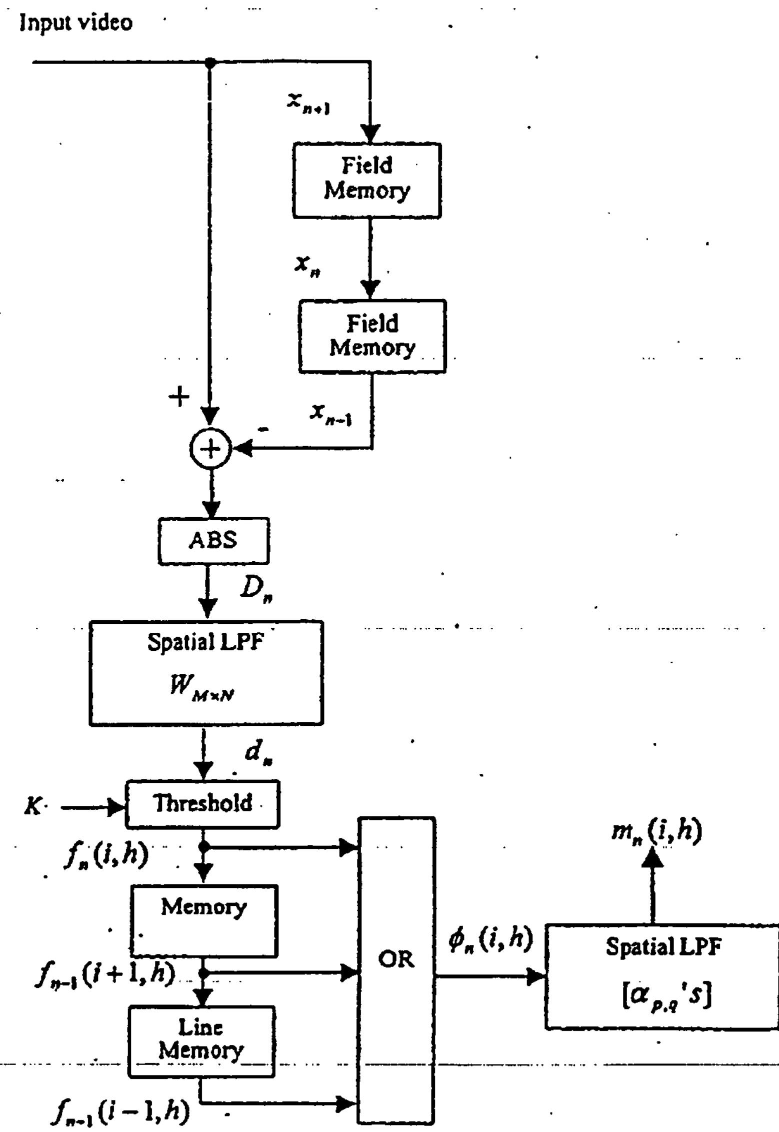

Input video
x_{n+1}
Field Memory
x_n
Field Memory
+
x_{n-1}
-
ABS
D_n
Spatial LPF
$W_{M\times N}$
d_n
K
Threshold
$f_n(i,h)$
Memory
$f_{n-1}(i+1,h)$
Line Memory
$f_{n-1}(i-1,h)$
OR
$\phi_n(i,h)$
Spatial LPF
$[\alpha_{p,q}'s]$
$m_n(i,h)$

FIG 4

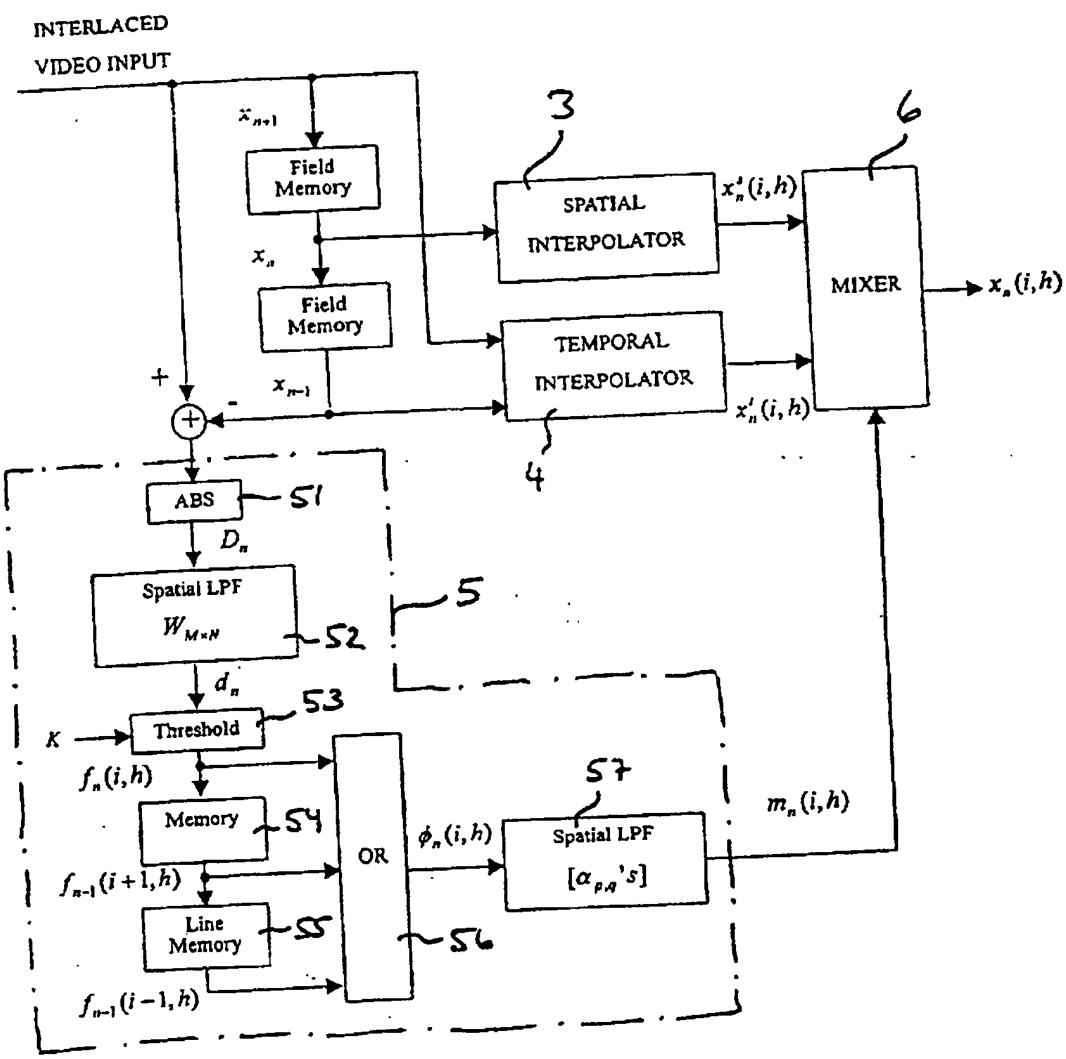

INTERLACED
VIDEO INPUT
x_{n+1}
Field Memory
x_n
Field Memory
x_{n-1}
+
-
3
SPATIAL INTERPOLATOR
$x_n^s(i,h)$
6
MIXER
$x_n(i,h)$
TEMPORAL INTERPOLATOR
$x_n^t(i,h)$
4
ABS
51
D_n
Spatial LPF
$W_{M\times N}$
52
5
d_n
Threshold
53
K
$f_n(i,h)$
Memory
54
$f_{n-1}(i+1,h)$
Line Memory
55
$f_{n-1}(i-1,h)$
OR
56
$\phi_n(i,h)$
57
Spatial LPF
$[\alpha_{p,q}$'s$]$
$m_n(i,h)$

FIG 5

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